**Lesson Title:**  Pendulum Demonstration Activity

**Subject area/ Course/grade level:** Science/ Energy/ 6th Grade

**Introduction:** This lesson assumes students have already been exposed to gravitational potential energy and kinetic energy. A raised pendulum bob has gravitational potential energy. Release it and the gravitational energy is converted into kinetic energy and the bob approaches the lowest point. As the bob swings to the other side, kinetic energy is again converted into gravitational potential energy.

**Lesson Length:**  1 hour

**Materials:**  meter sticks, string, bobs, hangers from marker board, pencil and paper

**Lesson Overview:**  Students will answer questions in relation to a pendulum demonstration.

**Tennessee Standards:**

GLE.0607.10.3 Explain the principles underlying the Law of Conservation of Energy

SPI 0607.10.2 Interpret the relationship between potential and kinetic energy.

SPI 0607.10.3 Recognize that energy can be transformed from one type to another.

**Lesson Objectives:** To investigate the principle of conservation of energy with a pendulum.

**DEMONSTRATION SETUP. (w/ all materials)** Set up a pendulum attached to a pendulum clamp with a string from a ring stand. Using two more ring stands, tie a string across the middle of the pendulum string to show the height the pendulum will be released from.

**(w/o all materials)** We worked with what materials we had, making our pendulum with string, a weight from a density kit, and hangers that are attached to the top of our white board. We also used the white board to mark our locations and a meter stick to give us even measurements. We used the meter stick to measure multiple points of even distance from the top of the whiteboard and make a solid line from our even measured points.

**ENGAGEMENT**

* Release the pendulum from the height marked by the measured line on the white board While watching the pendulum swing back and forth, students are asked to draw a diagram of a pendulum in motion. Students need to identify where the maximum gravitational energy and maximum kinetic energy positions are located. Draw a diagram to help them get started if necessary.
* Stop the pendulum and place a rod (or pendulum clamp) **(or have a student hold the meter stick)** across the pendulum path at the height of the string. Ask the students to predict what will happen to the pendulum when it hits the rod/stick after being released from line level. Do not allow students to answer out loud, but to make their predictions on their paper. Use the three choices listed below.

1) The ball will go higher than the horizontal string/line.

2) The ball will go just as high as the horizontal string/line.

3) The ball will not go as high as the horizontal string/line.

* After each student has had sufficient time to record their predictions, allow them to collaborate and write their answers on white boards in groups of three or four.
* Allow each group to present their prediction to the class. Try not to make any signals as to whether the answers are correct or incorrect. Be sure to ask each group to explain why they have chosen their answer. If they are guessing, and do not have any scientific reasoning behind their answer, get them to admit it. Then try to get them to identify any scientific process that would explain their answer.
* After each group has finished their presentation, release the pendulum and have each student record their observations. (*The pendulum should return to the level it was released.)*

**EXPLORATION**

* Now that students have had some exposure to this situation, it is time to apply scientific reasoning to new situations.
* Move the rod/string to a position above the release position (about 4 inches) and ask the students what would happen if the pendulum were released from the original height. Have them predict what they think will happen.

1) The ball will go higher than the horizontal string/line.

2) The ball will go just as high as the horizontal string/line.

3) The ball will not go as high as the horizontal string/line.

* Have students collaborate in groups of three or four and write their results on white boards. Each group should be allowed to present their results to the class.
* Release the pendulum and allow it hit to rod/stick located at a higher position. Allow students time to record their observations. *(The pendulum should return to the height it was released.)*
* Repeat this process for when the rod/stick is placed lower than the release position. Only move the rod/stick about 3 inches below. If you move it too low, there will not be enough string to reach the original height and the pendulum will loop over. *(The pendulum should return to the height it was released.)*

**ANALYSIS**

* After all groups have recorded their observation for all three situations, ask the students if there was a common result.
* Have students identify the maximum gravitational potential energy and kinetic positions for all three situations.
* After students realize that the final potential energy always equals the initial potential energy, define the Law of Conservation of Energy. Have students record this definition.
* Point out that all three experiments, the pendulum bob was released from the same height. Since all of that gravitational was eventually converted into kinetic energy and back to gravitational potential energy, the pendulum bob had to return to the same height.

**EVALUATION**

Students need to write a conclusion to this activity. Questions that need to be answered:

1) Describe the motion of the pendulum in terms of the conservation of energy. *( Explanations should state that the sum of the kinetic energy and gravitational potential energy is conserved.)*

2) How high can the rod be positioned before the pendulum bob is not able to return to the original height? *(The highest point is the height of the pendulum clamp.)*

3) How low can the rod be placed and the pendulum is still able to return to the original height? *( lf the rod is lower than 2/5th the distance between the lowest position of the ball and the height of the string, the ball does a loop-the-loop and does not return to the original height.)*

**EXTENSION**

* Have students design an experiment to investigate what makes the pendulum slow down and come to a stop.
* Have students design an experiment to investigate how the mass of the pendulum changes the motion of the pendulum. (NOTE: Be sure to keep the length of the pendulum the same when trying this experiment!).
* Have students design an experiment to investigate how the length of the string changes the motion of the pendulum.
* Have students design an experiment to investigate how the height of release changes the maximum kinetic energy at the bottom of the motion.
* If enough equipment is available, have students test to see if there is an upper limit or lower limit to where the rod is placed resulting in the pendulum bob not returning to its original height.